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A Guide to the

Care and Planting of Southern Pine Seedlings

December 1989

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Care and Planting of Southern Pine Seedlings

USDA Forest Service
Southern Region
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Atlanta, GA 30367-9102

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FOREWORD

This publication is a revision and modification of *Selecting and Planting Pine Seedlings* by David J. Moorhead (Cooperative Extension Service Bulletin 983, April 1988, Athens, GA). Members of a Technology Transfer Team on seedling care from lifting to planting are responsible for the writing and technical review of the material presented. Team members are:

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Our sincere thanks to other individuals who made suggestions and improvements and who furnished photos and other graphics. We also appreciate the fine work of Louise Foley and John Currie who did most of the editorial and layout work.

(Cartoons by Barry Nehr.)

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Key Points

- Survival in southern pine plantations has declined significantly in recent years because of poor seedling care. At various points between the nursery bed and the planting site, seedlings are "critically wounded" by events that nursery workers, truck drivers, and planters consider insignificant.
- Good care begins with conditioning, lifting, and packing in the nursery, includes transportation and storage, and ends when the seedling roots are in proper contact with the soil.
- Like other living plants, a tree seedling can live only briefly in the absence of moisture, nutrients, sunlight, or air.

Planning

- The first step in the planting process is to obtain the best species and seed source for the site. Poorly adapted seedlings grow poorly or die.
- The planting season in most of the South starts in December and ends in March. In Kentucky, Tennessee, and Virginia, planting often continues into April or early May.
- Seedlings should be ordered from the nursery well in advance to get the species, seed source, and type of seedlings that are needed.

Nursery Operations

- High-quality seedlings consistently survive and grow better than seedlings of lower quality.
- Nursery seedlings must be dormant if they are to be stored.
- Gentle lifting of seedlings from the nursery beds is critical for their future survival and growth.
- Pine seedlings are commonly packed in open-end bales, kraft-polyethylene (K/P) bags, or wax-coated boxes to protect them during transport and storage.
- Dipping or spraying seedling roots with kaolin clay or a synthetic gel improves storeability and field performance.

Storage and Shipping

- The ideal system includes cold storage at the nursery, refrigerated trucks for shipping, and cold storage at the district or distribution center. Seedlings in bales are able to dissipate heat better than those in bags or boxes.
- Longleaf pine seedlings and sand pine seedlings, seedlings with insufficient chilling hours, sources from, or seedlings grown near the Gulf and South Atlantic Coasts, and seedlings lifted late in the season are EXTREMELY PERISHABLE. If storage is unavoidable, it should be as short as possible.
- When there are no cold storage facilities at the planting site, take only as many seedlings as can be planted in a day.

Planting

- Roots should never be pruned after the seedlings leave the nursery.
- Delay planting if the soil is dry. To survive, a newly planted seedling must begin taking up water and nutrients quickly, and it cannot do so if the soil is dry.
- Large, level, open tracts are most easily planted by machine. Smaller or irregularly shaped tracts, sites with minimal site preparation, and rocky sites are more easily hand-planted.
- J-rooting and L-rooting slow early seedling growth. Slash, loblolly, shortleaf, and sand pine seedlings can be planted with root collars up to 3 inches below the surface of well-drained soil. In wet soils, plant only to 1 inch above the root collar.
- Plant longleaf seedlings so the bud is not buried or the root collar exposed. Their large root systems require larger and deeper planting holes than other pines.
- Maintain assigned seedling spacing.
- Pack soil firmly around roots to eliminate air pockets.
- Have a written contract that details all planting specifications, including transport and handling of seedlings, planting dates, spacing, and conditions when planting is to be suspended.

Safety

- Using the proper procedures and precautions will help ensure a completed job without injuries.
- Be very careful with pesticides.

Introduction

Despite constantly improving reforestation technology, many public and private forestry organizations report declines in early survival in southern pine plantations. Experienced managers have come to expect lower survival than they were used to 20 to 30 years ago, and they are seeing failures that cannot be attributed to insects, diseases, or adverse weather. The most common reasons for these failures are breakdowns in what can be thought of as the "reforestation system." At various points between the nursery bed and the field planting site, seedlings are "critically wounded" by events that workers consider to be insignificant. Combinations of these "insignificant events" add up to poor seedling survival or complete plantation failure.

This booklet is designed to encourage landowners, land managers, county foresters, forestry consultants, and nursery managers to be certain that their seedlings receive proper care. As a reminder, it reviews the elements of seedling care in an idealized reforestation system. For our purposes here, the system begins with lifting and packing in the nursery, includes transportation and storage, and ends when the seedling roots are in proper contact with the soil.

Despite recent progress in container seedling technology, the vast majority of southern pines raised for reforestation are bareroot seedlings. The use of container seedlings may some day reduce some of the quality-control problems described here. Most of the discussion in this booklet, however, applies to bareroot seedlings.

Concepts of Seedling Care

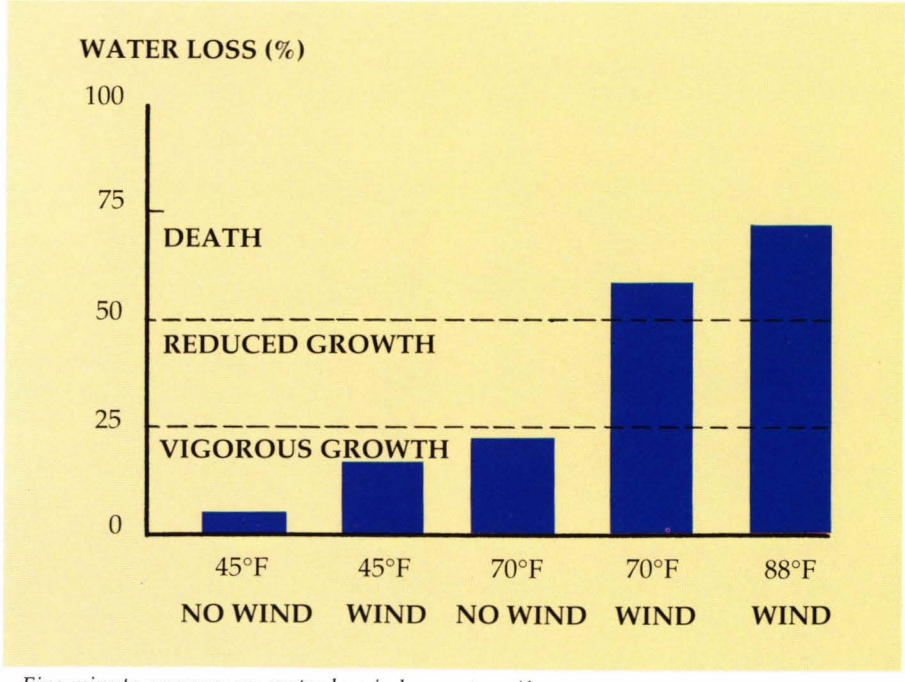
A pine seedling is a living plant. Like other plants, it can live only briefly in the absence of moisture, nutrients, sunlight, or air. When it is lifted from the nursery bed, it is deprived of nutrients, and its supplies of moisture and oxygen are highly artificial. Seedlings must be prepared in the nursery bed for the shocks they will have to endure, and they must be treated in ways that minimize those shocks. Even with the best of care, a seedling's ability to survive under these abnormal conditions is extremely limited.

The key concepts of seedling care are:

1. Conditioning seedlings in the nursery for lifting, shipping and storage.
2. Careful lifting and packing.
3. Minimizing seedling exposure to extreme temperatures, sunlight, and dry air.
4. Minimizing storage time.
5. Careful planting.

REMEMBER

The results of harmful events are cumulative. Short exposures may seem unimportant, but several harmful events can add up to a significant loss in survival and growth.



Five-minute exposure vs. water loss in bareroot conifers.

The Reforestation System

A typical reforestation system in the South includes the following components:

- A seed orchard where genetically improved seeds are grown.
- A nursery where high-quality seedlings are grown.
- A transportation and storage network that may include district storage units as well as storage at the nursery.
- Planting contractors (vendors) who plant the seedlings.

Often there are several organizations involved in this system and the coordination between the different organizations may be less than ideal. Sometimes there is a lack of coordination between units of the same organization! If, for example, an agency fosters the attitude that each branch is an independent unit, the responsibility and concern for seedling care must be passed on when the seedlings are shipped from one unit to another.

Unfortunately, the seedlings must suffer in silence. When their roots dry out, their stems are skinned, or their tops broken, they suffer and often die regardless of the type of organization or the degree of coordination. If only seedlings could talk, what stories they would tell!

- Stories of getting their roots "snatched" off by a careless lifting crew.
- Tales of cooking in the sun while they were waiting for a ride to the packing shed.
- Stories of being jammed into a bag with their tops twisted and no moisture on their roots.
- Stories of being dropped onto a concrete floor by a careless forklift operator.
- Tales of a sweltering ride to a district storage unit because the truck driver forgot to bring a tarp to cover the load of seedlings.
- Stories of being yanked out of a planting bag and then exposed to the sun and wind while the planter walked to the next field.

Successful reforestation depends on providing meticulous care throughout the system, regardless of the organization.

REMEMBER

Seedlings are highly perishable!

Planning the Planting Operation

Even if you have only a few acres to plant, you can increase your chances for success by knowing what to expect, anticipating problems, and deciding how to handle those problems. It pays to have a plan. Here are some of the questions that your plan should answer:

- What species and seed source will you plant?
- Exactly when will the seedlings be planted?
- Will bareroot seedlings do the job or should container seedlings be used?
- How many seedlings do you need, and where can you get them?
- How will the seedlings be packed?
- How, when, and where will you pick up the seedlings?
- Do you have a suitable vehicle to haul the seedlings?
- Can you pick up seedlings daily, or can you store them on the site?
- Will you be planting longleaf or sand pine, which are extremely perishable?
- How will planting be supervised to be sure that the work is of the highest quality?

(These questions are printed in the form of a checklist located at the end of this section.)

Species and Seed Source Selection

The first step in the planting process is to obtain the best species and seed source for a given site. For this decision landowners should seek the advice of county foresters, extension foresters, industry-landowner assistance foresters, consulting foresters, or ASCS/SCS personnel. It is important that the forester providing the advice be familiar with local soils, sites, and timber markets.

Genetically improved seedlings are a good investment because they perform better than unimproved seedlings. However, it is important to be certain that these seedlings are adapted to the planting site under consideration. Seed orchards are designed to produce genetically improved seeds suitable for specific geographic areas or physiographic provinces. They will not necessarily perform well when planted elsewhere. As with the selection of any plant, it is important to carefully match species and seed source to the planting site. A genetically improved seedling is of no value if it dies or grows poorly because it is not adapted to the site.

When seedlings from a poorly adapted source are planted, the plantation can fail or growth reductions can adversely affect yields throughout the rotation. Poor adaptation in the South causes early mortality from drought, freeze damage, ice (glaze) damage, fusiform rust infection, and slow growth.

PHOTO: HENRY BARBOUR

Left: Loblolly pine from a south coastal source; right: loblolly pine from a northern Piedmont source.

The Planting Season

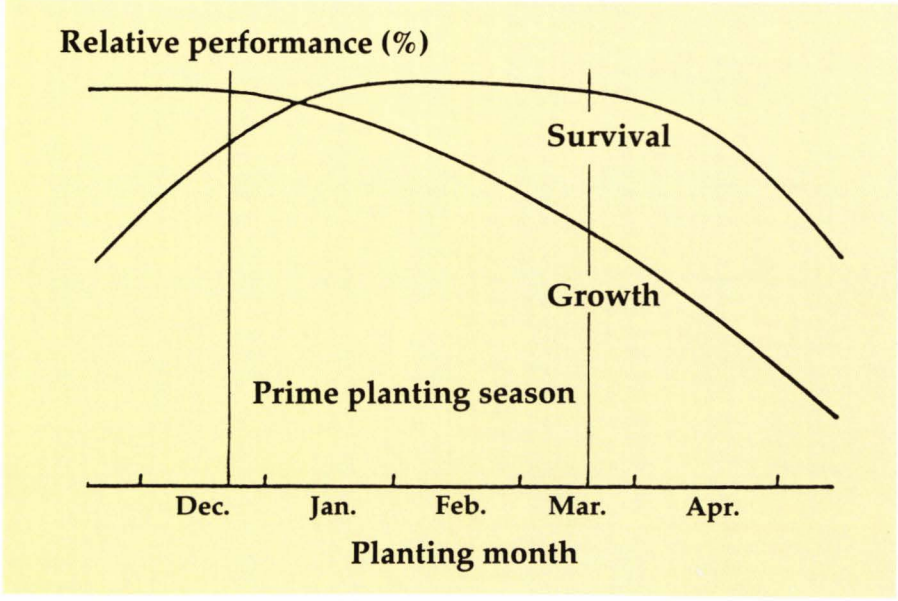
The planting season throughout most of the South usually starts in December and ends in March. In Kentucky, Tennessee, and Virginia, planting often continues into April, and on occasion includes early May.

A number of factors influence the start and duration of the planting season:

- The degree of dormancy of the seedlings determines whether they can be stored and the duration of storage. Bareroot southern pine seedlings seldom become truly dormant like the northern and western conifers. Seedlings in nurseries near the Gulf Coast and the South Atlantic Coast may stop shoot growth but root growth often continues as long as soil temperatures remain favorable.
- When seedlings cannot be stored, they must be lifted on a daily basis. For this to happen, the soil cannot be frozen, and the air temperature, windspeed, and relative humidity must be within safe limits at the nursery.
- The weather at the planting site must also be above freezing with the air temperature, windspeed, and relative humidity within safe limits.
- During the planting season operations at both the nurseries and the planting sites may have to be suspended due to severe weather.
- The end of the planting season is often determined by warm, dry weather in the spring. Under these conditions, seedlings suffer high mortality due to overheating and desiccation. In the nursery when seedlings "flush" (start height growth), they are very fragile and do not store well.

Fall Planting of Bareroot Seedlings – Fall planting has been done successfully when the seedlings are not stored. Some forestry organizations require planting contractors to pick up seedlings daily. In this case the nursery lifts and packs only sufficient seedlings for 1 day of planting. An advantage of early planting is that the seedlings become established during the winter and are ready to start shoot growth early in the spring. A disadvantage is that the seedlings may be actively growing in the nursery and therefore are extremely tender and difficult to handle. Early lifted seedlings also are extremely vulnerable to early frost.

Anyone considering fall planting should be aware of the risks associated with handling these early lifted seedlings.



South and Mexal (1984)

Diagrammatic representation of the relationship between planting date and subsequent performance of bareroot seedlings.

PHOTO: JIM BARNETT

Container seedlings.

Bareroot or Container Seedlings? – Seedlings that are grown, shipped, and stored in individual containers are becoming increasingly available in the South. They were originally developed for reforestation in the Scandinavian countries and Canada. Container stock can be planted either earlier or later in the year than bareroot stock. Early planting in the South can begin in October, allowing seedlings to become established before freezing weather occurs. Planting can extend into late spring and even summer on sites that are too wet to plant during the fall or winter with bareroot seedlings. The root system protection of container seedlings often helps to reduce seedling damage associated with the lifting, storage, and planting of bareroot seedlings. However, container seedlings are usually more expensive than bareroot seedlings. For additional information on container seedlings see the reference section.

REMEMBER

Seedlings must be protected from high temperatures, direct sun, wind, and freezing.

Advantages and disadvantages of southern pine container seedlings

Advantages	Disadvantages
Quickly produced	Require more attention while growing
Extended planting season	May cost more
Improved performance of some species	Bulky to handle
Perform well on adverse sites	May require more intensive site preparation
Efficient use of limited seeds	Smaller size
Uniform seedlings	

Barnett and Brissette 1986.

Ordering Seedlings

After the species, seed source, and type of seedling have been chosen, it is time to think about ordering your seedlings from a nursery. Plan ahead to allow time for adequate site preparation and to ensure availability of seedlings. Most southern nurseries begin taking seedling orders in midsummer—some begin as early as April. Place orders early so that you have enough seedlings of the proper species and seed source to meet your planting needs.

Before ordering seedlings . . . you need to know how many are needed and when they should be delivered.

To determine the number of seedlings to order consider the acreage to be planted and the planting spacing.

- Determine acreage by actual field measurement, or by estimation from up-to-date maps, aerial photos, or other records.
- Spacing of seedlings depends somewhat on your plans and objectives. Most pine plantations in the South are established with 600 to 700 seedlings per acre. A minimum of 600 seedlings per acre is required for participation in some Federal cost-share programs. In some cases forest industries are planting up to 1,000 seedlings per acre to maximize fiber production in short rotations. Most landowners, however, will get better returns by planting 600 to 700 trees per acre and managing for multiple products such as poles, sawtimber, chip-n-saw logs, and pulpwood.
- Seedlings are planted at different spacings to achieve the desired density. A general trend is toward increasing spacing between rows and correspondingly decreasing spacing within rows to improve access for fire control, thinning, and harvesting equipment.

Seedlings per acre by spacing

Spacing (ft)	Number of seedlings	Spacing (ft)	Number of seedlings
6 x 8	907	9 x 9	537
6 x 9	806	9 x 10	484
6 x 10	726	9 x 11	436
6 x 11	660	9 x 12	403
6 x 12	605		
		10 x 10	435
7 x 7	888	10 x 11	396
7 x 8	777	10 x 12	363
7 x 9	691		
7 x 10	622	12 x 11	330
7 x 11	565	12 x 12	302
7 x 12	518	12 x 15	242
8 x 8	680	15 x 7	414
8 x 9	605	15 x 8	363
8 x 10	544	15 x 9	322
8 x 11	495	15 x 10	290
8 x 12	453	15 x 15	193

PHOTO: BARRY NEHR

New Plantation

Calculation of the Number of Seedlings Required – The number of seedlings required for any spacing can be calculated by multiplying the distance between seedlings in rows (in feet) times the distance between rows (in feet) and dividing that product into 43,560 (the number of square feet in an acre).

Example: How many seedlings would be required to plant one acre at a spacing of 6 by 12 feet?

6 by 12 feet = 72 ft^2

$$\frac{43{,}560 \text{ } ft^2 \text{ per acre}}{72 \text{ } ft^2 \text{ per seedling}} = 605 \text{ seedlings per acre}$$

Having determined the number of acres to plant and the spacing and trees per acre, consider one more point. Add 10 percent for cull seedlings and shortages in the number of seedlings packed. Cull seedlings are too small, too large, damaged, or otherwise unsatisfactory for planting. (Identifying cull seedlings is covered in detail in the next section on seedling quality.) In effect, you will be ordering 10 percent more seedlings than you have calculated you need for planting. This overage will compensate for any shortage in the number of seedlings actually packed.

Most southern nurseries estimate the number of seedlings in a package by its weight. A bag that is intended to contain 1,000 seedlings may actually contain only 800 seedlings if the seedlings are unusually large and heavy, or possibly 1,200 seedlings if they are small and light. Differences in seedling moisture content or soil adhering to the roots will also disturb the accuracy of weight estimates of seedling numbers.

Example: How many seedlings should you order to plant 35 acres at a 7- by 10-foot spacing and allow for a 10-percent cull factor.

7 by 10-foot spacing = 622 seedlings per acre

35 acres x 622 seedlings per acre = 21,770 seedlings

10-percent cull factor: 21,770 x .10 = 2,177 seedlings

21,770 + 2,177 = 23,947 seedlings required

23,947 rounded to the next highest 1,000 = 24,000 seedlings to be ordered.

REMEMBER
Cull seedlings don't pay off!

Seedling Quality

High-quality seedlings are always a good investment. In contrast, investing land and labor in the planting of poor-quality seedlings never pays. Optimum quality seedlings have consistently performed better in both survival and growth than seedlings of lower quality.

PHOTO: ED CORDELL

High-quality seedlings have dense, fibrous root systems.

High-quality seedlings are a good investment!

Optimum characteristics of southern pine seedlings

Characteristics	Pine species		
	Longleaf	Loblolly and slash	Shortleaf
Stem length (inches)	—	10	8
Root collar diameter (inches)	9/16	7/32	3/16
Tap root length (inches)	6	6	6
Laterals (number)	←	5+ first order laterals	→
Winter buds	Present	Present	Present
Nature of stem	—	Stiff, woody, with bark	Stiff, woody, with bark
Mycorrhizae	Present	Abundant	Abundant
Shoot/root ratio (volume)	1:1	2 1/2:1	2 1/2:1

Lantz (1985).

Some nurseries cull seedlings to a uniform size before packing. Others attempt to produce a uniform seedling in the nursery bed to eliminate the added expense of hand culling after lifting. Culling before planting removes seedlings that are too large or too small to be planted. It also removes seedlings with broken or crushed stems and roots, stripped needles and missing bark. You should also look carefully for stem swellings indicating fusiform rust.

When seedling packages contain less than 10-percent cull seedlings, it is seldom cost-effective to cull at the planting site. Planters can be instructed to discard any small, weak, or damaged seedlings as they plant.

When packages contain more than 10-percent culls, the seedlings should be culled under careful supervision in a cool, high humidity area protected from sun and wind. As seedlings are removed from their packages, their roots should be dipped in water, clay, or a synthetic gel to reduce drying. Seedlings with roots that have already been coated with clay or gel should not be redipped. After culling, promptly repack seedlings in their original packages. Add more moisture if needed. Seedlings may be carried in buckets or tubs containing water or moist moss around the roots to keep them from drying out while being transported to the field. Do not leave seedling roots in water for more than 1 hour! These roots need air and cannot "breathe" under water.

A Reforestation Checklist for Landowners

___ The months of December to March are usually the best time to plant.

___ Select the best species and seed source for your site.

___ Bareroot or container seedlings?

___ Order your seedlings as early as possible.

___ Read about seedling quality and nursery conditioning.

___ Ask the nursery manager how the seedlings will be packed.

___ Decide how, when and where you will pick up the seedlings.

___ Do you have a suitable vehicle? (You should be able to keep the seedlings cool and protected from physical damage and/or chemicals, diesel fuel, herbicides, etc.)

___ Can you pick up seedlings daily from cold storage? If not, do you have suitable on-site storage?

___ Are you planting **extremely perishable** seedlings such as longleaf or sand pine? If so, special precautions are needed.

___ Have you arranged for proper supervision of the planting operation?

Nursery Operations

This section briefly describes some nursery operations that are critical for the production of high-quality seedlings. Landowners and planting contractors have little control over nursery practices, and most State, Federal, and forest industry nurseries can be relied upon to follow up-to-date practices in any case. If you are planning to buy seedlings from a small, independent nursery, you should assure yourself that the nursery in question is properly conditioning, lifting, and packaging its seedlings.

The few basics presented here are sufficient for a landowner or contractor to have that assurance. More detailed information on nursery management is readily available elsewhere (see Lantz 1985 in the list of references).

Conditioning

Seedlings that are actively growing in the nursery must be prepared for the shock of lifting, packing and storage. This conditioning treatment is meant to bring about a dormant condition in the seedling. Most southern nurseries reduce irrigation and fertilization in late summer and fall as part of this conditioning process. Undercutting, wrenching, and lateral root pruning are also used by many nurseries to prepare seedlings for lifting.

Nothing, however, induces dormancy quite as well as cold weather. The growth-dormancy cycle in southern pines, after all, is an adaptation to avoid plant injury in cold weather. To measure the probable depth of dormancy, many nursery managers record the number of chilling hours (hours when temperatures are between 32° and 46° F) after October 15. The geographic seed source of the seedlings determines the number of chilling hours required for dormancy. Some seed sources can be lifted and planted after 200 chilling hours, but storage should be for no more than 1 or 2 days. Most sources reach maximum dormancy after 400 chilling hours have accumulated.

PHOTO: HARRY VANDERVEER

Color of dormant loblolly pine seedlings in winter.

Under ideal conditions, these seedlings can be stored for up to 8 weeks. Seedlings with fewer chilling hours should be handled with extra care and planted within 2 weeks.

Winter coloration can be an additional indicator of dormancy. When needles change from green to a brownish red-purple, the seedlings usually are at least partially dormant. It is important to distinguish between the color of dormant needles and the reddish-brown of dead needles. Also, the needles of some species and seed sources do not change color in fall and winter.

Lifting

Gentle lifting of seedlings from the nursery beds is critical for their future survival and growth. Four factors must be considered if lifting damage is to be minimized: (l) weather, (2) method of lifting, i.e., hand or machine, (3) transportation to the packing shed, and (4) crew organization and supervision.

Weather – Optimum conditions for lifting seedlings are:

- air temperatures from 33° to 40° F
- relative humidity = 100 percent
- no wind
- overcast sky

When air temperatures are above 50° F, relative humidities are less than 50 percent, wind velocities greater than 10 mph, and it is a bright, sunny day, seedlings will lose moisture very rapidly. Under these conditions extra care must be exercised to prevent seedlings from drying out. When the soil is frozen, lifting should be delayed until the soil has completely thawed. Attempting to lift when the soil is frozen is certain to damage seedlings.

A number of organizations have developed weather classification systems with categories like normal, marginal, and critical, which are similar to fire danger ratings. The type of operation (lifting, shipping, or planting) is tailored to the weather category. For example, under critical weather conditions, lifting and planting operations should be postponed. When conditions improve to marginal, limited lifting and planting may be permitted but special care must be exercised.

System of lifting – The objective of lifting is to gently separate the roots of the seedling from the soil. Seedling harvesters are designed to lift pine seedlings quickly and efficiently with a minimum of damage. When weather and soil conditions are optimum, and the machine is properly adjusted and operated, seedlings are not damaged. However, if any part of the lifting system is not operating properly, seedlings can be severely damaged. Many organizations limit the use of seedling harvesters to optimum conditions, and lift by hand under other conditions.

Do:

- **Lift only when the weather is favorable.**
- **Coordinate the lifting system so that seedlings are protected at all times.**
- **Ensure that lifting machines are properly maintained and adjusted and that they are operated carefully!**

Do Not:

- **Permit harvesters to be operated under adverse weather conditions.**
- **Permit lifting crews to "slap" seedling roots against tubs, tractors, or boots.**
- **Permit harvesters (and particularly "root knockers") to be operated at high speeds.**

Transportation to the Packing Shed – After seedlings have been lifted, they are extremely vulnerable to desiccation. They dry rapidly when exposed to dry air, sun, and wind. At this stage, seedlings may be placed in tubs, canvas slings, or directly into bags or boxes. Some nurseries use large containers to transport seedlings in bulk to the packing shed.

During this part of the system, it is essential that seedling exposure be kept to a minimum and that physical damage be prevented.

PHOTO: AL STAUDER

Careful lifting protects seedlings from exposure.

Do:
- **Cover seedlings with wet burlap or canvas.**
- **Transport lifted seedlings to cold storage or the packing area at frequent intervals.**

Do Not:
- **Expose seedlings to sun, wind, or dry air.**
- **Stack tubs.**
- **Leave tubs, slings, or boxes in the sun or wind for any longer than absolutely necessary. In most cases the seedlings should arrive in the packing shed within 15 minutes after their roots leave the soil.**

PHOTO: CLARK LANTZ

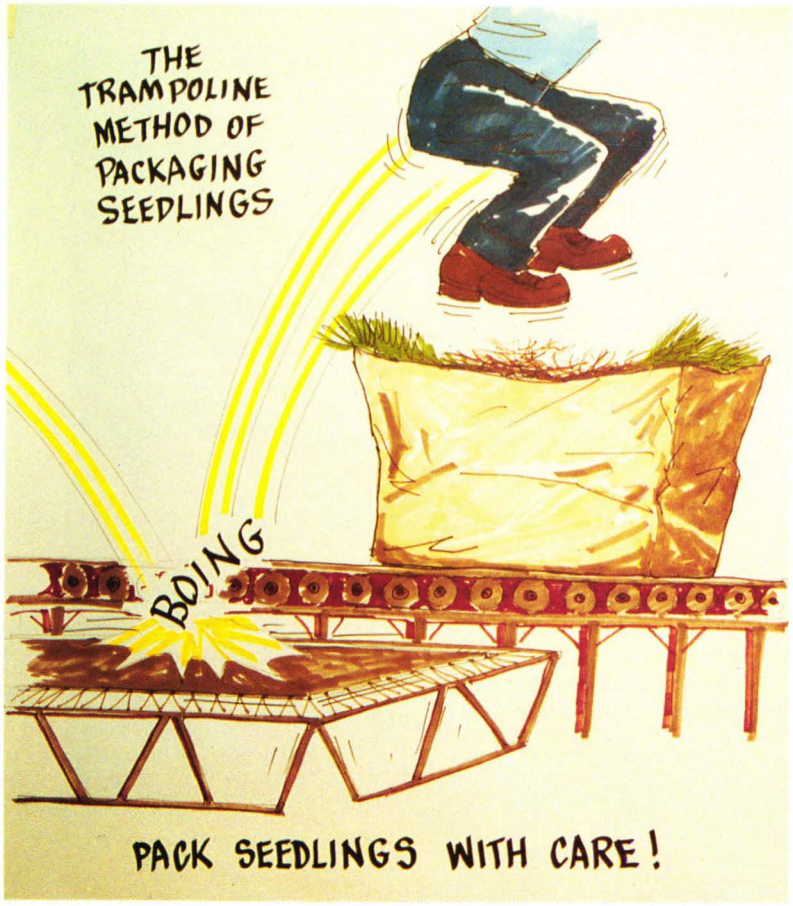
Careful handling after lifting prevents exposure.

Crew organization and supervision – It is essential that crews be trained for correct lifting. Do not assume that anyone understands the correct procedure for lifting seedlings until he or she has demonstrated the proper techniques.

If crews are not correctly supervised, harvesters are often operated too fast, roots and mycorrhizae are stripped and the cambium is bruised. Many months of good cultural practices and care can be lost in a careless moment during lifting!

Do:
- **Supervise the lifting operation very carefully.**
- **Insist that weather conditions and/or risk categories are followed.**

Do Not:
- **Permit a lifting crew to work without proper supervision.**



Packing

Pine seedlings are commonly packed in open-end bales, kraft-polyethylene (K/P) bags, or wax-coated boxes. These packages protect the seedlings during transport and storage. **Proper storage conditions must be provided from the time of lifting until planting to maintain seedling quality.** Good supervision is essential in the packing operation to ensure that the seedlings are handled carefully.

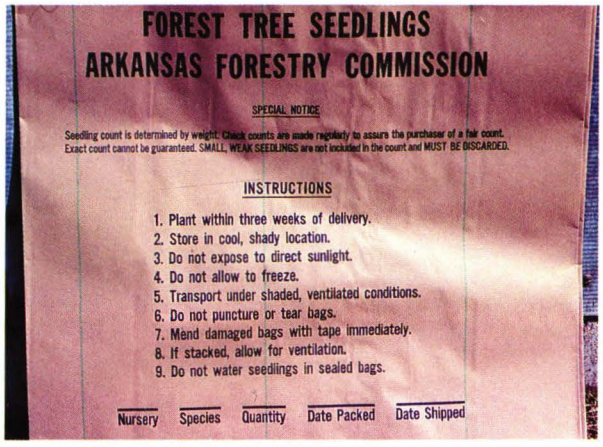

FOREST TREE SEEDLINGS
ARKANSAS FORESTRY COMMISSION
SPECIAL NOTICE
Seedling count is determined by weight. Check counts are made regularly to assure the purchaser of a fair count. Exact count cannot be guaranteed. SMALL, WEAK SEEDLINGS are not included in the count and MUST BE DISCARDED.
INSTRUCTIONS
1. Plant within three weeks of delivery.
2. Store in cool, shady location.
3. Do not expose to direct sunlight.
4. Do not allow to freeze.
5. Transport under shaded, ventilated conditions.
6. Do not puncture or tear bags.
7. Mend damaged bags with tape immediately.
8. If stacked, allow for ventilation.
9. Do not water seedlings in sealed bags.
Nursery
Species
Quantity
Date Packed
Date Shipped

PHOTO: CLARK LANTZ

PHOTO: CLARK LANTZ

Important messages about seedling care can be printed on the seedling packages.

Some factors to consider in selecting seedling packages

Factor	Bales	K/P Bags	Boxes
Watering	Water must be added weekly unless roots are coated	No water needed	No water needed
	[Do not add water to seedlings with coated roots]		
Vulnerability to temperature buildup	Open-ends allow dissipation of heat	Rapid heat buildup	Better insulation than bales or bags
Protection from physical injury to seedlings	Open-ends lack protection	Good protection when properly packed and strapped	Best protection – although seedlings will shift inside box if not handled carefully
Relative cost	Least	Intermediate	Most expensive
Stacking	Use spacers if stacked more than two deep	Use spacers if stacked more than two deep	Can be stacked up to four deep
Printed care instructions	Difficult due to limited space	Adequate space	Best surface for instructions

In general, the K/P bags are ideal if cold storage can be provided from packing until planting. These bags are very vulnerable to heat buildup – both internal (heat of respiration) and external (sun + warm air). Seedlings in storage too long may ferment! When cold storage is not available, the seedlings in K/P bags should be planted immediately.

Bales are often used where cold storage is not available or where conditions are variable or unpredictable. Seedlings shipped to private landowners are often packed in bales due to the uncertainty of storage conditions. Bales can be safely stored in sheds or unheated buildings where they will be protected from freezing and the temperature will range from 35° to 50° F.

Root Coatings

Dipping or spraying seedling roots with several different materials improves storeability and field performance. Kaolin clay has been used for many years at rates of 3 to 3-1/2 pounds of clay per gallon of water. The optimum mixture is thick enough to cause roots to barely stick together. Seedlings with kaolin-coated roots have consistently survived better than seedlings with untreated roots in a number of studies. The primary advantage of the clay appears to be in protecting against moisture loss when exposure occurs during planting.

PHOTO: BARRY NEHR

Packing with clay slurry.

PHOTO: AL STAUDER

Carefully packed K/P bag of seedlings.

Pesticides, such as benomyl, may be easily added to the clay slurry. A mixture of 5 percent (AI) benomyl in kaolin clay improves storeability, brown-spot resistance, and planting survival of longleaf pine seedlings. Lower concentrations of benomyl should be used with other species.

In recent years, some "superabsorbent gels" have been applied to protect seedling roots. These materials are easier to mix and spray than clay and not nearly as messy to handle. Preliminary results indicate that the **synthetic** gels are effective.

REMEMBER

Do not add water to seedlings with coated roots as the clay/gel may be washed off the roots.

Storage

Between lifting and planting in the field, seedlings may be stored, moved, and re-stored one or more times. Methods of storage and treatment during storage can vitally affect the physiological condition of the seedlings and their subsequent survival.

Storage Facilities

Temporary storage of seedlings between lifting and packing should be inside a packing shed where temperatures can be controlled so that seedlings will not freeze, become heated, or dry out.

Warehouses or storage sheds are subject to temperatures ranging from subfreezing to about 80° F or higher. Sheds should be equipped with racks to provide good air circulation around all packages of seedlings. Racks for baled seedlings should be slanted so that water supplied to the upper end of the bale can move through the bale, and excess water can drain from the bale. A water supply must be available for the entire storage area.

Refrigerated storage rooms or coolers should be kept at 33° to 40°F. The high relative humidity in most cold storage units is beneficial for seedlings. Relative humidity of 85 to 95 percent is probably about normal for these coolers. When relative humidity is low, the walls of the cooler can be sprayed periodically with water. Automatic humidity controls are also available, but the relative humidity is difficult to control at the low temperatures maintained in the coolers. Because of the trend toward packaging seedlings in waterproof, sealed containers, precise humidity control is important only when exposed seedlings or seedlings in bales are stored.

Bale Storage

Pine seedling tops in open-end bales transpire continuously, translocating moisture from the roots and often the packing material. Water is also lost directly by evaporation from the packing media of bales. The rate of transpiration and evaporation is strongly affected by the air temperature and relative humidity surrounding the bale and by the rate of air movement. Bales packed with moss or similar material must be watered every week.

After storage of about 1 week in bales, the survival rate of the seedlings may decline, and the decline will increase with time. Baled seedlings stored without refrigeration should be planted within 1 to 4 weeks after lifting. Clay-packed bales in shaded, ventilated storage generally require no watering for at least 3 weeks, as roots of clay-treated seedlings do not dry as quickly as seedlings in moss-packed bales.

Other Considerations in Nursery Storage

Seedling handling and storage requires considerable space to ensure good air movement around packages and to ensure that the seedlings in storage for the longest time are shipped first ("first in = first out"). Storage areas must be

equipped with racks or pallets to provide air circulation. Packages not stored on pallets or racks should be separated by spacers to allow air circulation. Most large storage operations are mechanized with forklifts to handle packages of seedlings on pallets or racks.

The season of lifting and the physiological condition of the seedlings strongly affect the storeability of pine seedlings. Nondormant seedlings lifted in the fall do not store well. If seedlings are planted immediately after lifting, their survival may be satisfactory, but storage of even 2 weeks can cause survival to drop below satisfactory levels. In contrast, seedlings that have made the first flush of growth in early spring before lifting have been stored in bags in cold storage, with subsequent adequate survival.

Package temperatures should be monitored in all storage facilities. These temperatures should be checked in several packages in well-distributed locations. Seedlings will heat, particularly if packages are placed too close together. In one cold storage study, the internal temperatures of bags with poor air circulation averaged 22° F higher than those with good air circulation. In this study piling bags more than two deep resulted in a 10° F increase in internal bag temperatures.

No machine is free of trouble, and a cold storage unit is no exception. Refrigerated units should be equipped with warning devices such as a bell or flashing light to inform the nursery staff that a malfunction has occurred. In enclosed areas, the heat produced by seedlings can quickly change a cold storage facility into a warm storage facility. Frequent inspections are necessary to ensure that temperature controls are functioning properly. Constant attention to all factors involved in the storage operation will pay off in healthy seedlings for planting.

Do:

- **Stack seedling packages no more than 2 deep and use spacers to provide air flow between packages.**
- **Inspect for torn bags, dry roots, and high temperature.**

Do Not:

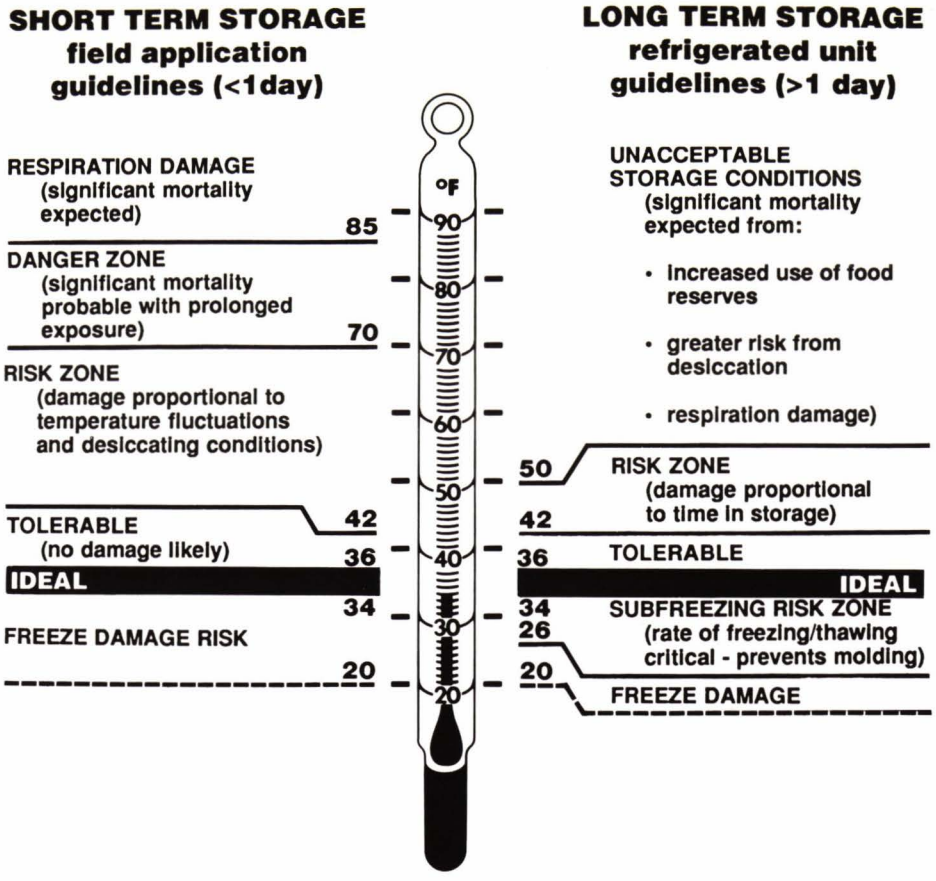
- **Assume that cold storage units operate properly without regular inspections.**

Storage Guidelines

Bales	Bags	Boxes
Optimum temperature:	← 33° - 40° F →	
Relative humidity: 90 percent +	Not critical when bags are sealed and intact.	Not critical when boxes are sealed, waxed, or lined.

REMEMBER

Seedlings deteriorate in storage – even under the best of conditions. Plant them as soon as possible!



France and Hollis (1988)

Temperature guidelines for dormant bareroot pine seedlings

Maximum storage duration and recommended care for dormant loblolly and slash pine seedlings

Storage facilities[1]	Package	
	K/P bag	
	Box	Bale
Refrigerated 33 - 40° F	8 weeks from lifting – repair damaged bags	8 weeks from lifting – water as needed[2] (do not water seedlings with coated roots), allow drainage
Shed 33 - 50° F	3-4 weeks from lifting – repair damaged bags	4-6 weeks from lifting – water every week (do not water seedlings with coated roots), allow drainage

[1]With either type facility, store in racks and stack bags or bales only two high.
[2]Frequency of watering is dependent on moisture conditions in cold storage. Always use water under low pressure.

(Modified from Williston 1974.)

REMEMBER

Seedlings must be protected from high temperatures, direct sun, wind, and freezing conditions.

Shipping

The ideal system for handling seedlings includes cold storage at the nursery, refrigerated trucks for shipping, and cold storage at the district or distribution center. Many large forestry organizations in the South have such a system. Unfortunately most small, nonindustrial landowners do not have access to these facilities. For this reason, many State nurseries pack seedlings in bales rather than closed containers. Seedlings in bales are able to dissipate heat better than those in bags or boxes.

When several thousand seedlings must be shipped on an uncovered truck, the risk of damage is high. In warm, sunny weather, heat can build up inside seedling packages very rapidly. Packages should be loosely covered with a tarp, and spacers should be placed between the packages to permit air flow. The heat of respiration combined with solar heating may cause internal package temperatures to rapidly reach the lethal temperature of 118° F. However, seedling quality may deteriorate at temperatures as low as 50° F.

Do:

- **Stack seedling packages no more than two deep and use spacers to provide air flow between packages.**
- **Use covers over packages to prevent desiccation, freezing, and overheating.**
- **Haul seedlings at night to avoid high day temperatures.**
- **Inspect covers, tarps, and refrigeration units during the trip.**

Do Not:

- **Park trucks in the sun during coffee breaks, lunch stops, or pit stops.**
- **Leave seedlings on the truck overnight if there is danger of freezing temperatures.**
- **Throw, crush, or physically damage the seedlings.**

PHOTO: CLARK LANTZ

Perishable Seedlings

The following seedlings are extremely perishable and should be planted immediately:

- longleaf pine seedlings
- sand pine seedlings
- seedlings with less than 400 chilling hours
- seed sources from the Gulf and South Atlantic Coasts
- seedlings grown in nurseries near the Gulf or South Atlantic Coasts
- seedlings lifted late in the season (particularly if these have started height growth)

If storage is unavoidable, it should be as short as possible. Every additional day of storage will reduce the survival and growth potential of these seedlings!

Planters often delay longleaf planting because it is difficult and time consuming and usually is a small fraction of the total workload. Storing longleaf seedlings is an invitation to disaster! The planting of longleaf stock must be given priority over other species.

Delivery of Seedlings

The planting season in the South begins in December and ends between February and April, depending on location. The optimum period in the Gulf Coast States is from mid-December to mid-February. Farther North, the planting season is often extended into March and April. Weather conditions often force an extension of the planting season causing problems with proper seedling storage as the weather becomes warmer.

PLAN AHEAD

Locate a cold storage unit with space available during the time of planting.

When you accept delivery of your seedlings from the nursery, you should be sure that they are protected from direct sun, high temperatures, and freezing temperatures. If you pick up the seedlings from the nursery or distribution point, provide cool, shaded conditions for transport. Arrange to pick up seedlings in late afternoon and schedule long-distance hauling at night to prevent heat buildup from the sun.

If an open truck or trailer is used for shipping, a tarp can be used to shade the seedlings, but be sure to allow for ventilation under the tarp and around the seedlings to prevent heat buildup. To prevent water loss from open-end bales, avoid exposing the bales to wind or moving air during transport. Avoid stacking bales or bags of seedlings over two high without providing space between packages for air circulation and support to prevent crushing.

If cold storage cannot be provided at the planting site, only enough seedlings for 1 day of planting should be picked up at the cold storage unit or distribution center. On-site storage for a day can be improvised with a trailer parked in the shade or a tarp stretched between several trees. Heat-reflective "space-tarps" can be utilized in the field to protect seedlings from heat and drying. Remember: However, the shaded area moves during the day. Seedlings left in the shade in the morning are likely to be in direct sun in the afternoon.

PHOTO: SOUTH CAROLINA FORESTRY COMMISSION

Portable seedling coolers are rented by the South Carolina Forestry Commission.

Where large, remote tracts are planted, refrigerated trailers are often parked on the tract, cooled with a self-contained refrigeration system. Some refrigeration units can be operated with a portable generator. There are also slip-on "ice-boxes" that can be carried on 1/2- or 3/4-ton pickup trucks. The S.C. Forestry Commission will rent portable seedling coolers that can be operated on 110 volts or with a self-contained generator.

REMEMBER

Planting dead seedlings is a waste of time, land, and money.

Planting

The key to a seedling's survival after planting is the ability of the root system to quickly begin taking up water and nutrients. Newly planted seedlings cannot get moisture from dry soils. Delay planting under these conditions until sufficient rainfall occurs to recharge soil moisture. If the soil is flooded, and drainage does not occur until late March or April, plant container seedlings when conditions become favorable. The container seedlings can be stored in the shade for several weeks if necessary. They must be handled carefully and watered as conditions require.

The decision to continue or postpone planting when planting conditions deteriorate is a difficult one. It is expensive to let a planting crew play cards because the temperature has increased or decreased beyond acceptable limits. It is doubly expensive however to plant seedlings under conditions that guarantee failure. In this case, not only the cost of planting is lost, and the cost of the seedlings is lost, but also site preparation may need to be repeated the following year.

A common situation in the South occurs at the end of the planting season in March or early April. The air temperature and windspeed increases during the day, and the relative humidity drops drastically. This is our traditionally high-risk fire weather. Should planting continue or be postponed?

PHOTO: OTIS JONES

High-quality seedlings are essential for a successful plantation.

Depending on the site, either hand or machine planting can be the most efficient and reliable option. Large, level, open tracts are most efficiently planted by machine, while smaller or irregularly shaped tracts, sites with minimal site preparation, and rocky sites are more easily hand-planted.

Show planters the correct depth to plant seedlings. The proper depth varies with soil and site conditions, but seedlings should be no deeper than the length of the dibble bar or the foot on the planting machine. Shallow planting results in early seedling mortality, particularly during early spring and summer droughts. On many old-field sites, the soil contains a compacted plowpan that must be broken by subsoiling to permit deeper planting. Subsoiling should always be done several months before planting to allow the soil to settle.

Slash, loblolly, shortleaf, and sand pine seedlings can be planted with root collars up to 3 inches below the soil surface, provided the planting hole is deep enough to avoid root deformation and the soil is well-drained. Improper planting resulting in J-rooting and L-rooting slows early seedling growth. In wet soils with a high water table, plant seedling root collars only 1 inch below the soil surface. Never plant seedlings with the roots exposed above the soil surface.

Continue or postpone planting?

Characteristic	Continue planting	Postpone planting
1. Seedling quality	Deterioration due to exposure under unfavorable weather conditions	Deterioration due to prolonged storage
2. Probability of acceptable survival	Dependent on local conditions	Decreases as the season progresses
3. Procurement of additional seedlings	Better early in the season	Becomes increasingly difficult as the season progresses
4. Soil moisture	Usually more favorable early in the season	Often soils dry out as the season progresses
5. Availability of planters	Good	Questionable

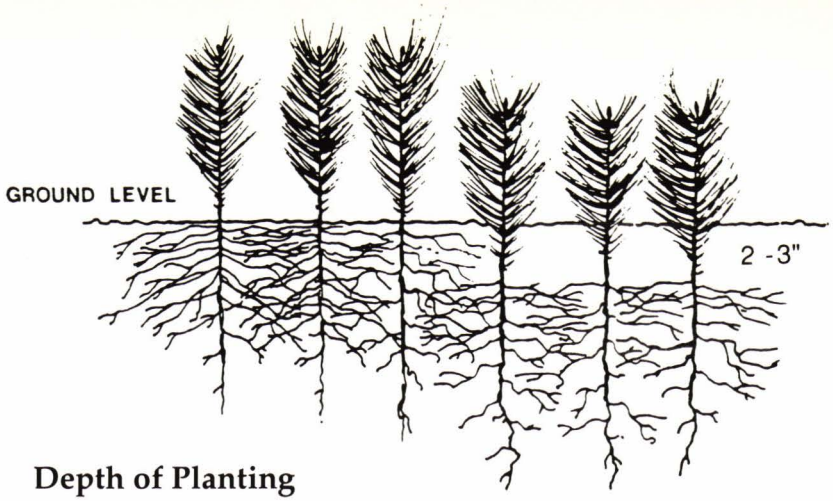
Hand vs. machine planting

Characteristic	Hand	Machine
Topography	No restrictions	10-percent slope or less
Erosion potential	None	Significant
Contour planting required	No	Yes
Rocky sites (large rocks)	Can modify spacing	Difficult to maneuver
Logging debris	No restrictions (large amounts on site reduce production)	Must be free of large logs/stumps
Degree of site preparation required	No restrictions	Must be free of large logs/stumps
Poorly drained soil	No restrictions	Difficult when wet
Average production	800-2,000/day (1 person)	7,000-11,000/day (2-person crew)
Probability of high planting quality with large seedlings (e.g., longleaf)	Low	High

Longleaf pine requires special care in planting and great attention to planting depth. Plant longleaf seedlings so the bud is not buried or the root collar exposed. The large tap root and lateral root system of high-quality longleaf seedlings requires larger and deeper planting holes than other pines. Hand planters should use the larger-type KBC dibble, rather than the narrow OST dibble. Machine planting is always preferred.

Regardless of the planting method, plant seedlings at the correct spacing and depth so that the roots are not deformed, and the soil is firmly packed around the roots to eliminate air pockets.

Have a written contract that details all planting specifications including transport and handling of seedlings, planting dates, spacing, and conditions when planting is to be suspended (site too wet or too dry, freezing weather, or summer-like conditions). The contract should provide for inspections during planting to ensure that quality standards are met before payment is made. This is especially important when planting with cost-share programs. Cost-share payments may be withheld if the quality of the work is low. Of course, top-quality planting is always in the best interest of both the landowner and the vendor.



Virginia Division of Forestry

Depth of Planting

Plant slash, loblolly, shortleaf, and sand pine seedlings 2 to 3 inches deeper than they grew in the nursery.

REMEMBER
Always supervise all steps of the planting operation!

Seedling Care at the Planting Site

When there are no storage facilities at the planting site, take only as many seedlings as can be planted in a day. If time and logistics permit, arrange to have seedlings delivered twice a day. Load and transport packages carefully to avoid damage to seedlings.

Seedling quality deteriorates quickly with careless field storage and handling. Always provide a shaded storage area. A tarp can be erected to shade the seedlings. Heat-reflective tarps are very effective. Be sure that there is ample ventilation to prevent heat buildup in the packages. Do not lay a tarp directly over the seedlings during the day. Be sure to leave plenty of air space between the tarp and the seedling packages and also between individual packages. Temperatures inside seedling packages can quickly exceed 50° F on sunny days, even when air temperatures are moderate. Temperatures exceeding 50° F will quickly reduce the quality of the seedlings.

Ideally seedlings not planted should be returned to cold storage. If this cannot be done, cover seedlings left overnight in the field with a tarp at sunset to protect against freezing. Repair any tears or holes to the packages with duct tape. Repackage the seedlings as necessary.

Check seedlings carefully.
Look for:

- Fermentation smell (smells like silage)
- Black color and/or mold on roots
- Bark "slips" on stems or roots
- Chlorotic, yellow needles
- Seedlings warm to touch

When giving seedlings to the planters, open and empty only one package at a time. Make sure that planters carry seedlings in bags or buckets. Never allow seedlings to be hand-carried with roots exposed while planting. Have water and clay or synthetic gel dips available to keep seedling roots moist. Do not leave seedling roots in water, clay slurry, or gel solution for more than 1 hour—repackage them in their original or in new packages.

Heeling-In – The practice of removing seedlings from their packages and planting them in shallow ditches is called "heeling-in." This was common in the Soil Bank era. **Currently, heeling-in is not recommended since many roots and mycorrhizae are lost in the process of digging the seedlings.** Careful storage in packages is more effective than "heeling-in." Mycorrhizae are beneficial associations between tree roots and soil fungi that increase the size and efficiency of the root system.

REMEMBER

Roots and mycorrhizae are essential for good survival and growth!

Root Pruning – Root pruning should never be done after the seedlings leave the nursery. The physical damage done to the seedlings and the additional exposure are both highly detrimental to survival and growth.

Frozen Seedlings

Seedlings frozen for more than 1 day should be discarded. Seedlings frozen for short periods (less than 1 day) can be thawed and safely planted. Let them completely thaw slowly before attempting to separate and plant. Always handle frozen seedlings very carefully as roots are very brittle. Freeze-damaged root systems will appear limp and discolored, and root tips will easily slough off in handling. Discard seedlings that appear to have suffered freeze damage. Longleaf pine seedlings are extremely vulnerable to cold injury. If longleaf seedlings have been frozen for even a short period, they should be discarded.

If there is some doubt about the condition of seedlings, it is safer to discard them rather than to plant dead or dying seedlings.

Do:
Examine stored seedlings carefully, looking for signs of freeze damage.

Do Not:
Take the chance of planting dead seedlings.

Hand Planting

An experienced hand-planting crew can average 1,500 seedlings planted per person per day—inexperienced crews far less. Production ranges from 600 on very rough sites to 2,000 in open fields. It is essential, however, that seedlings be planted carefully—quality is more important than quantity.

Crews work most efficiently when the planters are aligned at a 45° angle to the direction of planting. The lead person establishes the line and sets the pace. The others in turn guide on this spacing and maintain the proper distance between rows. The fastest planters should always work at the leading end of the crew and be paid a little more per hour as an incentive.

Planting crew organization should be flexible and adapted to the size of area, terrain, distance from road and other factors. An efficient crew is 10 to 12 planters with a nonplanting supervisor. When the planting area is a long way from the truck, it will pay to have a seedling supplier who does nothing but keep the planters supplied with trees and drinking water.

Most planters use a dibble bar or hoedad, with a blade at least 4 inches wide and 10 inches long. Seedlings can be carried in a bucket, but a planting bag is more efficient. The planting bag is strapped around the planter's waist and holds several hundred seedlings. Seedlings are dipped in a synthetic gel or packed in the bags with wet moss. The bag protects seedlings from sun and wind. The planter removes one seedling at a time after the dibble has been used to open the planting slit. DO NOT allow planters to carry seedlings in the hand while planting as seedlings will rapidly dry out. Just a few minutes of exposure to wind and sun can kill the seedlings. Always provide planting bags or buckets and insist that seedlings be kept moist at all times.

REMEMBER

Supervision is the key to successful planting.

PHOTO: BARRY NEHR

Hand planting.

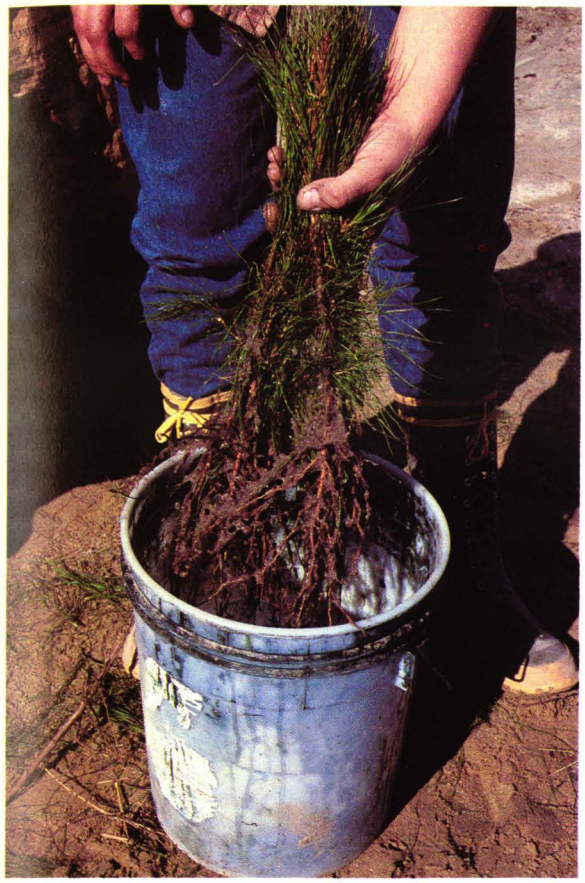
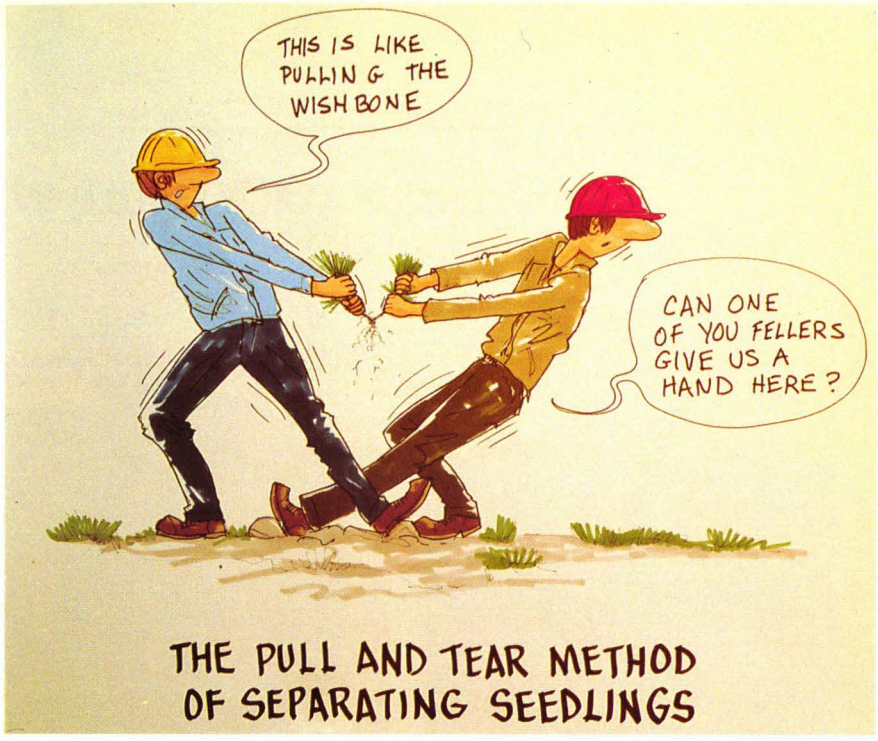


PHOTO: DAVID MOORHEAD

Dipping seedling roots in a gel solution restores lost moisture.

Have a supervisor at the site to ensure that planting proceeds smoothly and properly. The supervisor should watch for poor practices such as stripping-off roots to make planting large seedlings easier, slower planters discarding seedlings to catch up with the faster planters, shallow planting, loose packing of soil, and carrying seedlings in hand during planting.

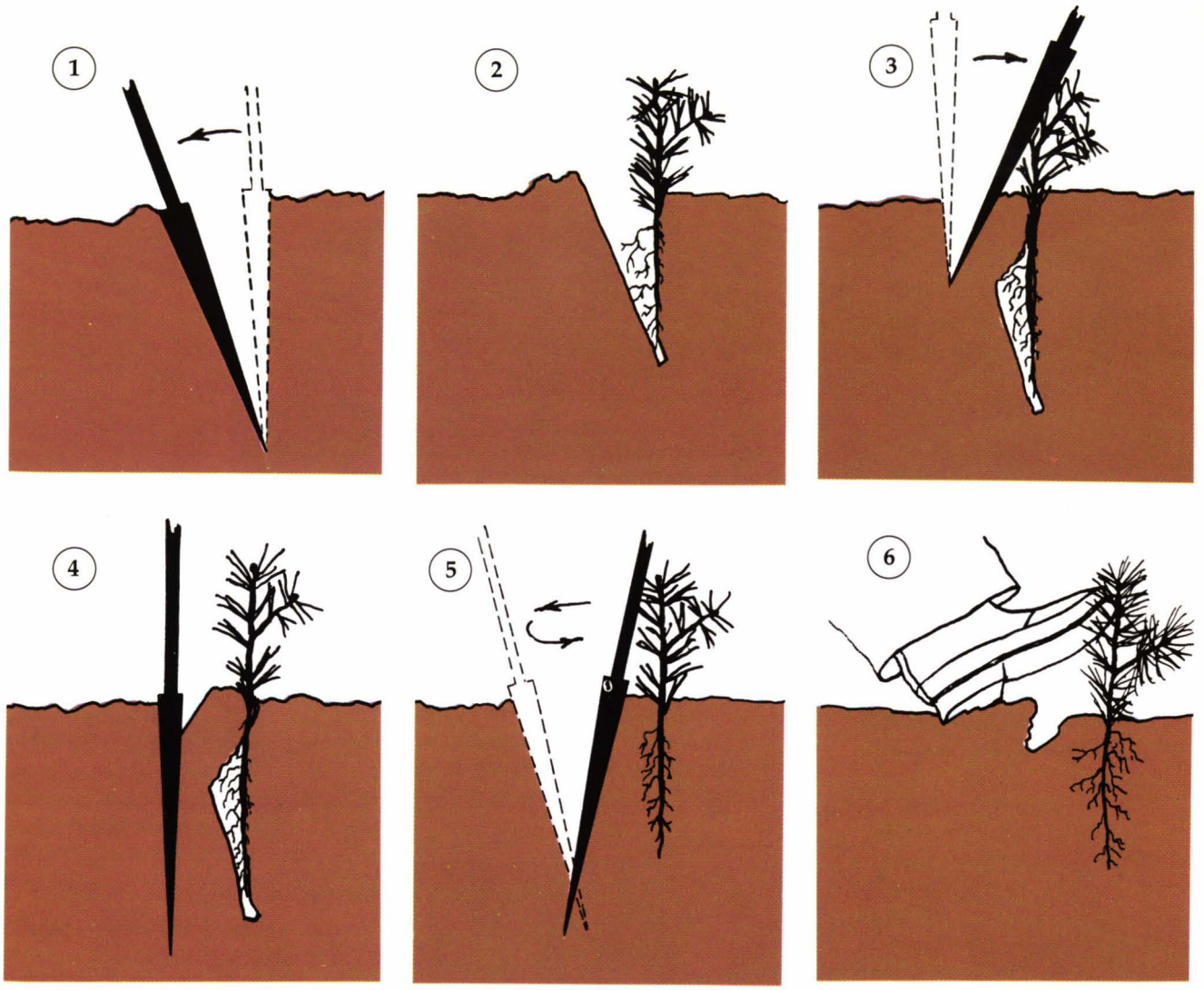
Make frequent checks to ensure that correct spacing is maintained. Measure the distances of planted seedlings within and between rows. Proper packing is necessary to eliminate air pockets around the roots. Check by grasping several needles at the tip of the seedling between thumb and forefinger and gently try to pull the seedling from the soil. The needles should break if the seedling is firmly packed. A shovel can be used to dig around seedlings to check for J-rooting.


THIS IS LIKE PULLIN G THE WISH BONE
CAN ONE OF YOU FELLERS GIVE US A HAND HERE?
THE PULL AND TEAR METHOD OF SEPARATING SEEDLINGS

The planting supervisor is the key to good production. Supervisors are needed to maintain the quantity and quality of work. They must drop unwilling or incapable planters from the crew, place faster planters at the head of the planting line, and constantly check planting spacing. They should spot check the work of each planter about five times each day to verify the quality of their work. Look for:

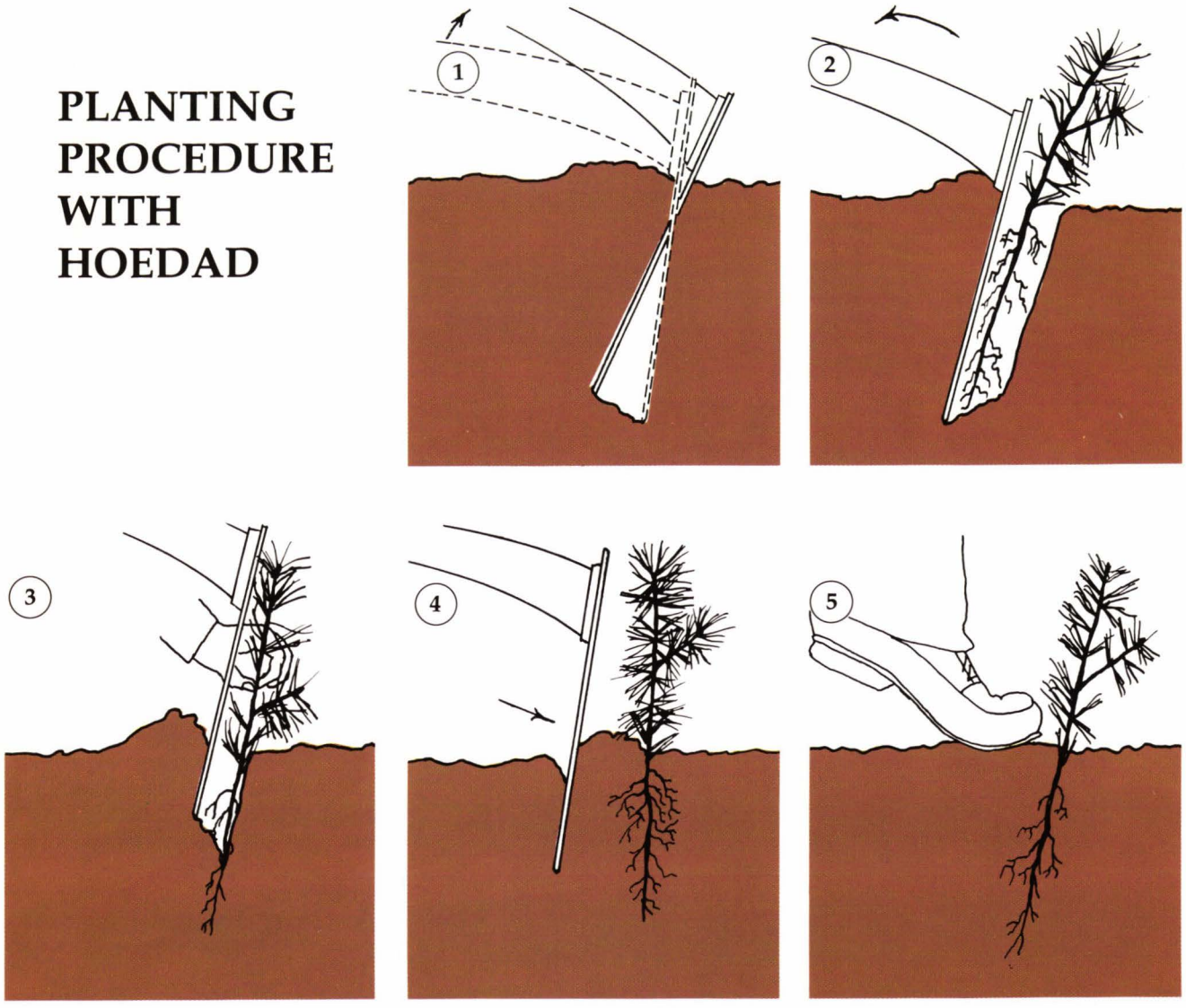
1. Tearing roots when seedlings are pulled from the package or the carrying bag.
2. Trimming roots with thumb or knife. This results in short or stripped roots. Root pruning should never be done after the seedlings leave the nursery.
3. Not closing bale or bag when seedling supplies are replenished.
4. Not having moss, mud, or gel in planting bags.
5. Carrying trees in the hand while planting.
6. Failing to open a hole the full length of the planting bar, resulting in U- or J-roots.
7. Failing to push the tree to the bottom of the hole and then pulling it up to the proper position, again resulting in U- or J-roots.
8. Failing to close the hole tightly.
9. Spacing too close. If planters are allowed to do a lot of talking, they tend to bunch up and plant seedlings too close together.
10. Discarding of seedlings by slow planters who wish to conceal their lack of production.
11. Planting under living trees that will not be removed or killed.
12. Planting seedlings without consideration of wildlings already on the ground.

PLANTING PROCEDURE WITH DIBBLE



1. Insert the dibble straight down into the soil to the full depth of the blade and pull back on the handle to open the planting hole. (DO NOT rock the dibble back and forth as this causes soil in the planting hole to be compacted, inhibiting root growth.)
2. Remove the dibble and push the seedling roots deep into the planting hole. Pull the seedling back up to the correct planting depth (the root collar should be 1 to 3 inches below the soil surface). Gently shake the seedling to allow the roots to straighten out. DO NOT twist or spin the seedling or leave the roots J-rooted.
3. Insert the dibble several inches in front of the seedling and push the blade halfway into the soil. Twist and push the handle forward to close the top of the slit to hold the seedling in place.
4. Push the dibble down to the full depth of the blade.
5. Pull back on the handle to close the bottom of the planting hole. Then push forward to close the top, eliminating air pockets around the root.
6. Remove the dibble and close and firm up the opening with your heel. BE CAREFUL to avoid damaging the seedling.

PLANTING PROCEDURE WITH HOEDAD



1. Strike blade almost vertically, full depth of the blade, into the soil. Pull up on the handle to break the soil loose at the bottom of the hole. **Caution** – Avoid raising the handle more than a few inches. The hole will fill with soil and the seedling will be shallow-rooted.

2. Slide hand down handle almost to the blade. Pull back and down on the handle to form a pocket on far side of the blade. With the other hand, immediately roll the seedling roots into the pocket to the full depth of the hole.

3. Hold seedling in place while sliding the hoedad blade out of the hole. Loose soil should fall into the hole holding seedling in place.

4. Pull blade completely out of the hole and push soil against planted tree with the tip of the blade.

5. Use foot to firm the soil against the seedling. Do not step on or bruise seedling with your foot.

PHOTO: BRUCE BALDWIN

Careful machine planting places seedlings at the correct depth and spacing.

Machine Planting

A well-trained and supervised planting crew and a machine that is correctly matched to the site, can plant 7,000 to 9,000 seedlings per day. The condition of the planting site is important in selecting the proper size of the machine. Old fields and cropland can be planted with light-duty planters pulled by wheeled tractors having 20 plus horsepower. Rough sites require heavy-duty planters pulled by large farm tractors or crawler tractors of 50 plus horsepower.

Seedlings are fed into the machines by two systems—a manual system in which each seedling is placed into the trench by hand, and an automated system in which seedlings are placed in mechanical "fingers" that position them in the planting trench.

When seedling packages must be carried on the tractor, protection from high temperature must be considered. Never place seedlings on top of the tractor engine, radiator, or near the exhaust pipe.

Check planting performance frequently to ensure proper planting quality, particularly when soil type, texture, moisture, or debris changes on the site. Items to look for include:

1. Maintain proper adjustment by carefully checking planting performance under actual site conditions.

2. Adjust packing wheels to completely close the planting trench from top to bottom.

3. Be sure seedlings are planted straight and at the proper depth.

4. Follow the planter and use a shovel to open the planting trench to judge root placement. L-rooting (or "swept roots") is a common problem with machine planting.

5. Adjust the planter to open the trench to maximum depth and make sure that seedlings are placed at the proper depth and released quickly so the roots are not dragged along the trench.

6. Be sure that the tractor is not dripping oil or hydraulic fluid.

Container Seedlings

Seedlings in containers can be stored for extended periods because their roots are protected. They must be protected from freezing and desiccation however. The limited soil volume of the container makes the seedlings very susceptible to desiccation in sunny and windy conditions. Store in partial to full shade and water frequently to maintain adequate moisture throughout storage and planting.

Container seedlings may be planted by machine or by hand. With either method, it is critical that the planting hole be deep enough so that the top of the root plug can be completely covered with soil. If the top of the root plug is not covered with soil, it will dry rapidly by a wicking action, and the seedling will die. Careful covering also reduces frost heaving of fall planted seedlings. Take special care when planting container longleaf pine seedlings. Plant too deep and the bud is covered, plant too shallow and the root plug is exposed, rapidly drying out the rooting medium. Planting depth is critical for longleaf pine—both container and bareroot. Longleaf pine is an exacting species!

Planting Conditions

Keep a close check on the site and environmental conditions at planting time. Planting on bright, sunny, windy days in dry soil can result in rapid seedling mortality. Dry soil is difficult to pack around the seedling roots and cannot supply needed moisture when seedlings need it the most. When soils are too wet, especially clay soils, machine planting can compact the soil, reducing both survival and growth.

Optimum planting weather is a temperature between 35° F to 60° F, a relative humidity greater than 40 percent, and a windspeed less than 10 mph. When air temperature is in the 70's or low 80's, humidity is less than 40 percent and windspeed is 10 mph or greater, delay planting until conditions improve. Do not plant in freezing weather or summer-like conditions. The North Carolina Forest Service has developed a system of weather classification for planting (see appendix).

Trouble shooting guide for machine planting

Observation	Possible causes
L- or U-Root	Insufficient weight or hydraulic pressure on frame or planting box Need hydraulic fluid Worn coulter (riding on hub) Gap between coulter and shoe too great (buildup of debris) Worn planting shoe or foot Soil too dry Planting seedling too deep in trench
Seedlings damaged by packing wheels	Packing wheel misaligned Packing wheels too close
Seedlings thrown out of ground or planted at angle	Angle of packing wheels too flat Releasing seedling too late Mud buildup on packing wheels
Seedlings not well packed	Not enough weight or pressure on packing wheel or packing coulter Hitch not adjusted correctly Packing wheels too far apart Soil too hard
Trash in holes	Need scalper or V-blade
Seedlings planted too shallow	Site-prepared soil not settled Releasing seedling too soon

Balmer and Williston 1974.

DO YOU THINK THIS WIND WILL HAVE A DRYING EFFECT ON THE SEEDLINGS?
NAH!
YES... WIND HAS A VERY STRONG DRYING EFFECT ON SEEDLINGS!

Evaluation of the Planting Job

In tree planting, the desired objective is a fully stocked stand of healthy trees in a "free-to-grow" condition. The plantation should be monitored to be sure that objective is met. The monitoring process begins shortly after the seedlings are planted and should continue through at least three growing seasons.

After planting, sites should be periodically revisited to check for such things as animal damage, frost heaving, and other unforeseen events that sometimes occur. If severe damage has occurred shortly after planting, there may be time to replant.

After a full growing season, plantations should be checked to determine stocking, survival, and release needs. Systematically spaced 1/100th-acre plots can be used to determine the number of live trees on the area as a whole, the areas needing replanting or release. The type of competing vegetation and its abundance and severity should be inventoried. Seedlings that are overtopped by competing woody vegetation are at risk of dying or having normal growth greatly reduced.

Note: Plantation evaluation forms and instructions are located in the appendix.

REMEMBER

All of the investment in tree breeding, nursery culture, and careful handling can be lost if planting is done carelessly!

PHOTO: CLARK LANTZ

A successful plantation!

Safety First

Safety comes first on any job. Here are some tips for preventing injuries:

General: Package no more than 1,000 seedlings in a bale or bag to prevent back strain.

Haul workers and tools or supplies together only when tools are enclosed in a toolbox that is securely fastened to the bed and securely closed or when tools are fastened together and securely lashed to floor.

Use safety cans for storing and handling fuel.

Planting: Use care when handling seedlings treated with chemicals. Wash hands thoroughly with soap and water or other hand cleaner after handling chemicals. Change clothes if they become soiled with chemicals.

See that tree planters wear nonskid boots; snug fitting clothing; cuffless, snag-proof, and tear-resistant trousers; gloves; and long-sleeved shirts.

Make sure planters in wooded areas wear hardhats and eye protecting devices (safety glasses, goggles, or eye shields). Provide the planting crew with pocket First Aid Kits and equip the work truck with a larger First Aid Kit.

Make snake bite kits available.

Provide wire cutting pliers with carrying holsters to remove metal strapping around bales and bags.

Carry planting bars at the side (not on the shoulder when walking). Keep planters at least 10 feet apart when they are carrying tools.

Advise the planters to watch their footing on rocky slopes and in and around gullies.

Insist that tractor and planter operators wear hardhats.

Put a warning signal device on planting machines so the planter can signal to tractor operator to stop in case of emergency.

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Appendix

Appendix A

Important Questions a Landowner Should Ask a Tree Planting Contractor

Prior to entering a contractual agreement for tree planting, a landowner should obtain the following information from potential contractors.

1. Will vendor sign a contract with landowner? (Helpful to provide sample contract.)
2. How long has contractor been planting trees?
3. How are crews handled and supervised?
4. Are crews paid on an hourly or a production basis?
5. Does contractor have access to cold storage for seedlings?
6. Can contractor provide references or take landowner to previous planting job? (Both preferred.)
7. How will contractor care for and handle seedlings on site?
8. If contractor is providing seedlings, what is provenance of seeds or seedlings. (This information should be verified by a forester not connected to contractor.)
9. How are seedlings transported by contractor to planting site?
10. How will contractor verify trees planted per acre?
11. What method will contractor use to plant seedlings (dibble, hoedad, or machine)?
12. Will contractor guarantee planting job for survival?
13. How will contract differences be resolved?

GENERAL CONDITIONS REGARDING TREE PLANTING CONTRACTS

- Any extra work requested by the landowner will increase the cost.

- The contractor agrees to perform all work in a workmanlike manner and according to the methods described previously.

- The landowner accepts full responsibility for damage to any person or property caused as a result of inaccurate marking or designation of boundary lines around the area in which the work is to be performed, or around the property in general, and will hold the contractor harmless from any claim against the contractor for damage or liability resulting from such cause.

- The contractor may not subcontract any part of this contract without prior written approval of the landowner.

(Frank A. Roth II, Alabama Cooperative Extension Service)

. . . . . .

Appendix B

Tree Planting Contract

This contract is entered into on this the _____ day of _____,

19___, by and between _____ (Landowner)

and _____ (Contractor) for tree planting

on _____ acres in _____ County, _____ (State).

Each party agrees to the following terms of this contract, which is binding on both parties.

The Landowner agrees:

1. To accurately describe, show, or have the contractor show where the seedlings are to be planted and to provide rights of ingress and egress to the planting site for all personnel, materials, and equipment to perform the planting operation.

2. To provide the contractor with sound, plantable seedlings, unless other arrangements have been made to supply them.

3. Upon satisfactory completion of planting, according to the terms of this contract and upon presentation of a proper invoice by contractor, and verification of correct planting, to pay the contractor in the amount of $_____ per acres for each acre planted.

The Contractor agrees:

1. To notify the landowner or his agent when he intends to begin planting.

2. To properly care for and plant seedlings according to the following specifications.

Planting:

A. Seedlings will be planted in rows approximately _____ feet apart and seedlings will be planted _____ feet apart in the rows.

B. The intent is to plant approximately _____ well-spaced seedlings per acre, without varying more than an average of 50 seedlings per acre from this count. In any event, no more than 800 or less than 600 seedlings will be planted per acre (350-450 for hardwoods).

C. Contractor will plant only one seedling at a time.

D. Planting hole must be free of trash.

E. Seedlings will be planted at least as deep, and no more than 3 inches deeper, than they grow in the nursery.

F. Roots will be firmly packed at the top and bottom of the hole. They will be straight, not balled, twisted, or U-rooted.

G. Seedlings will be protected from heating and freezing. They will be kept moist and cool at all times and their roots will not be exposed to drying while planting.

H. Tree seedling roots will not be pruned or cut by contractor unless approved in writing by the landowner or his agent to contractor.

3. Contractor shall guarantee that seedlings will be planted so that planting will meet the specifications for planting under a cost-share program. Contractor accepts responsibility for familiarity with cost-share program specifications.

4. The effective date of the agreement shall be _____, 19___. The contractor shall complete the work in this contract by _____, 19___, at which time this agreement shall terminate.

It is understood and agreed by both parties that in the event of a disagreement that cannot be resolved by the two parties that an arbitration team will be selected in the following manner: The contractor and landowner will select a member each and these two members will select a third member. The three-member team will collectively arrive at a remedy for the disagreement that will be honored by the landowner and the contractor.

We, the undersigned agree to the terms of the above contract.

_____	_____
Landowner	Witness
_____	_____
Date	Witness
_____	_____
Contractor	Witness
_____	_____
Date	Witness

Appendix C

OPERATIONAL GUIDELINES FOR HANDLING SEEDLINGS

Kenneth F. Jeffries[1]

Abstract. – Realizing that seedling mortality is not caused by any one phase of the reforestation process, the North Carolina Division of Forest Resources has developed seedling handling standards for lifting, delivery and storage, and field planting.

Like most of you, we have experienced varying degrees of seedling survival problems over the last few years. The high cost of site preparation and the increased use of improved seedlings make poor survival much harder to take and also harder to explain to the boss and/or landowner.

We feel that poor practices in the nursery will reduce survival to some degree. If improper practices continue through storage, transport, and planting, the cumulative effect will most likely end in a planting failure.

We have developed standards for seedling processing in three general categories: (l) Nursery lifting and processing standards, (2) District/county delivery and storage standards, and (3) Field handling and planting standards. (Note: Only (2) and (3) are reproduced here).

These three stages of the reforestation process are divided into three classes of days: (l) Normal conditions, (2) critical conditions, and (3) severe conditions.

As you might expect, any one of these requirements could be below par, but excellent conditions in the other requirements could compensate and allow a normal condition to exist. Just as in setting fire readiness plans, some experience and judgment is required. I will go through the highlights of these standards.

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[1] Senior Staff Forester, Nursery and Tree Improvement, North Carolina Division of Forest Resources, Department of Natural Resources and Community Development, Raleigh, NC.

(Note: This material is condensed from Jeffries 1983)

District/Contractor Delivery and Storage Standards

Normal Day

Temperature: 35° F to 75° F
Relative humidity: 50 percent +

Delivery

1. Vehicles used for transporting seedlings will have a cover to shade and protect seedlings.
2. Bags/bundles will not be stacked over three deep per layer unless spacers are used to provide air circulation between layers.
3. At least 12 inches of air space between top of bags/bundles and cover will be left to avoid heat buildup.
4. Vehicles will not be parked in direct sunlight. In case of emergency stops or breakdowns when stops exceed 45 minutes, seedlings should not be planted until their condition has been determined.
   a. Things that indicate seedling deterioration:
      (1) Sour smell – fermentation
      (2) Yellow needles
      (3) Trees hot to the touch
      (4) Mold developing

      If any of these conditions exist, contact the District Staff Planting Coordinator prior to planting.
   b. Things that indicate dead seedlings:
      (1) Bark, especially on roots, slips off easily
      (2) Cambium layer has turned brown

      (Do not plant if these conditions exist.)
5. Inspect and repair torn bags immediately.

Storage

1. Store seedlings in a building, shed, etc. that will protect from freezing, heating, and direct sunlight.
   a. Ideal temperature 35° to 38°F. (These temperatures usually can be maintained only with refrigerated units.)
      (1) Bags stored under ideal conditions can be kept at least 3 months (usually longer).
      (2) Bales with seedlings dipped in clay slurry will keep from 8 to 10 weeks.
      (3) Bales with seedlings packed in moss will keep from 8 to 10 weeks, but will require watering of bales at least two times per week.
   b. Temperatures inside storage area from 38° to 50° F.
      (1) Bags stored under these conditions can be kept up to 3 or 4 weeks.

(2) Bales with seedlings dipped in clay slurry will keep 2 to 3 weeks.

(3) Bales with seedlings packed in moss will keep 2 to 3 weeks but will require watering at least two times per week.

c. Temperatures inside storage area above 50° not exceeding 75° F – seedlings should be removed within 3 to 5 days.

2. Bags/bundles should be stacked on pallets or slats and should not be stacked over two deep without spacers to allow air circulation between layers.

Critical Day

Temperature: 76° to 85° F
Relative humidity: 30 to 50 percent

Delivery

1. Field delivery in nonrefrigerated vehicles should be held to a minimum. Seedling delivery from a nonrefrigerated storage point to destination should not exceed 1 hour's time.
2. Vehicles used for transporting seedlings will have a cover to shade and protect seedlings.
3. Bags/bundles will not be stacked over two deep per layer unless spacers are used to provide air circulation between layers.
4. At least 12 inches of air space between top of bags/bundles and cover will be left to avoid heat buildup.
5. Vehicle will not be parked in direct sunlight. In case of emergency stops or breakdowns, seedlings should not be planted until their condition has been determined.
   a. Things that indicate seedling deterioration:
      (1) Sour smell—fermentation
      (2) Yellow needles
      (3) Trees hot to the touch
      (4) Mold developing
   b. Things that indicate dead seedlings:
      (1) Bark, especially on roots, slips off easily
      (2) Cambium layer has turned brown

      Do not plant if these conditions exist.
6. Inspect and repair torn bags immediately.

Storage

1. Store seedlings in a building, shed, etc. that will protect from freezing and heating. If temperatures inside storage area is above 75° F, do not store seedlings more than 24 hours.
2. Bags/bundles should be stacked on pallets or slats and should not be stacked over two deep without spacers to allow air circulation.

Severe Day

Temperature: 85° + or 32° F or less
Relative humidity: 30 percent or less

Delivery

1. Field delivery in nonrefrigerated units should not be made when the temperature is 85° F or higher.
2. Field delivery in noninsulated units when the temperature is 32° F or less will be made only if the vehicle is covered adequately to prevent freezing.
   a. Caution – seedlings can heat excessively on a cold day if vehicle is parked in the sun and seedlings are dead packed, preventing air circulation.
   b. Unload seedlings immediately upon arriving at destination.
3. Inspect and repair torn bags immediately.

Storage

1. Seedlings should not be stored in bags/bundles for more than a few hours at temperatures above 85° F.

   Lethal temperatures occur in bags/bundles at 118° F, but seedlings can be weakened or damaged if the temperature in the bag/bundle remains at 85° F for very long.
2. Do not store seedlings in an area where the temperature is 32° F or less.
   a. Do not allow seedlings to freeze
   b. If trees have not been frozen more than 36 hours:
      (1) Thaw seedlings slowly
      (2) Determine condition
   c. If frozen more than 36 hours, then seedlings most likely have been severely damaged and should not be planted.

Field Handling and Planting Standards

Normal Conditions

Temperature: 35° to 75° F
Relative humidity: 50 percent +
Wind: Less than 10 mph
Soil moisture: 0-30 buildup

On-Site Storage of Seedlings

1. Bags/bundles should not have prolonged exposure to direct sunlight. Store the seedlings in a shaded location at all times.
2. If no shade is available at planting site, improvise a portable shelter such as a lean-to made of opaque plastic, canvas, or plywood.

3. Bags/bundles should not be stacked in layers more than two deep without spacers. Spacers allow air to circulate freely around the seedlings and keep them cool. (Heat builds up even at low storage temperatures when the seedlings are stored in direct sunlight or without air circulation – especially in sealed bags).
4. Keep close check on seedlings stored at the planting site and water **uncoated** roots of seedlings in bags or bundles if roots begin to dry. Be careful not to puddle water in bags, as excess water can drown root tips or promote mold on the seedlings.
5. Do not water **coated** roots of seedlings since the water will remove the coating. Since the coating of roots will not give absolute protection against moisture loss, restrict the exposure of the roots the same as if they were uncoated.
6. Inspect and repair torn bags immediately.
7. Keep **opened** bags closed tightly by folding flap over bag and laying flat-side down or by placing a band or cord firmly around bag. Keep in shade.
8. Keep **opened** bundles covered at all times with wet burlap. Keep in shade.
9. If **opened** bags of seedlings, coated or uncoated, must be kept for **over 2 days** before planting, seedling roots must be dipped in water and bag tightly closed, or heel seedlings in.
10. If **opened** bundles of seedlings are not used shortly after opening, they should be heeled in.
11. Store trays of containerized seedlings in shade and keep root plugs wet until seedlings are planted. During storage, open book-type containers and check moisture of root plugs.

Culling Nonplantable Seedlings

1. Open only one bag/bundle at a time. Be careful not to leave open more than a few minutes.
2. Remove only a small number (handful) of seedlings at a time. Do not allow the roots to be exposed to the sun or wind any longer than 5 minutes.
3. Cull 1-0 **loblolly** or 2-0 **white pine** seedlings that have:
   a. Broken, skinned or weak stem
   b. Fermented smell
   c. Mold on needles
   d. Slippery bark
   e. Root collar smaller than 1/8th inch
   f. Root collar larger than 3/8th inch (large seedlings must be balanced; have a balanced root-to-top ratio)
   g. Root systems less than 4 to 5 inches long
   h. Roots systems longer than 12 inches if more than 50 percent of the laterals must be pruned in order to plant
4. Cull 1-0 **longleaf** seedlings if root collars are smaller than 1/4th inch or tap roots shorter than 7 inches.
5. Cull **containerized** pine seedlings that are very small and poorly developed. Also, cull seedlings if root plug has become dry and hard.
6. Cull **hardwood** seedlings having root collars smaller than 1/4th inch. Also, cull broken or skinned seedlings and seedlings with stems that have not hardened off.
7. Roots must be kept visibly moist at all times. If not visibly moist, dip roots in water. If being placed back in bag, shake excess water from roots prior to placing in bag to prevent puddling. (Do not dip **coated** seedlings). Close bags properly.
8. For best results, assign one trained person to be responsible for culling seedlings. Closely supervise and check on culling procedures. Be sure the person(s) is properly trained.

Critical Conditions

Temperature:	76° – 85° F
Relative humidity:	30 – 50 percent
Wind:	10 mph +
Soil moisture:	30 – 80 buildup

On-Site Storage of Seedlings

1. Bags/bundles should have minimum exposure to direct sunlight.
2. Otherwise, very closely follow **same** standards for Normal Conditions.

Culling Nonplantable Seedlings

1. Make a special effort to keep roots of seedlings exposed to sun and wind for no longer than 3 minutes.
2. Otherwise, follow very closely the **same** standards for Normal Conditions.

Severe Conditions

Temperature:	32° F or less; ground frozen * or 85° F +
Relative humidity:	30 percent or less
Wind:	15 mph +
Soil moisture:	80 + buildup

* Note: If weather forecast indicates cold temperatures that will freeze ground for several days immediately after planting, do not plant.

On-Site Storage of Seedlings

1. Seedlings will not be stored at planting site under these conditions. Bags/bundles should be stored in a building, shed, etc. that will protect from freezing and/or heating.
2. Refer to Storage Standards as given under **District/Contractor Delivery and Storage Standards,** Severe Conditions.

Culling Nonplantable Seedlings

1. Culling will not take place at planting site.
2. Culling is permissible in a building, shed, or other protected area.
3. When culling in such an area, follow very closely the same standards for Normal Conditions.

Tree Planting Operation

All planting should STOP, unless localized site exceptions exist.

Localized Site Exceptions

If a localized site exception to the severe soil or weather conditions does exist, planting may continue. Follow the standards for Critical Conditions.

Summary

We realize this system will not solve all problems with survival, but we believe it is a start in the right direction.

Pressures from tree planters and from within our own organization will probably prevent strict adherence to the guidelines, but if we can reduce plantation failures by 50 percent, we will have made the effort worthwhile.

Appendix D

Inspection and Evaluation of Planting Jobs

The success of your planting job depends on careful attention to all of the factors previously mentioned. However, to ensure that you have received a quality job, a thorough inspection is needed.

Stocking represents the number and distribution of living seedlings over the plantation. Depending on spacing, 600 to 800 trees are usually planted per acre. Adequate stocking information is used to determine whether replanting a portion or the entire stand is necessary. A systematic sampling system is the best method to sample stocking. The number of properly planted live trees is counted in fixed-area plots, usually circular plots. These plots are uniformly spaced across the plantation.

One sampling method is to use 1/100th acre circular plots (11.78 ft radius) spaced in cardinal directions as follows:

Acreage limits	No. of plots	Spacing
1-60 acres	1 per acre	211 ft (3.2 chains)
61-90 acres	1 per 2 acres	297 ft (4.5 chains)
91 + acres	1 per 3 acres	363 ft (5.5 chains)

Once the plot center is established, all trees inside the plot are counted and a "four-needle" test is performed. Each plot is tallied on the planting inspection form. All seedlings inside the plot are checked for above-ground problems, and are tallied on the form. Above ground problems include cull seedlings, shallow seedlings, excessively deep seedlings, or seedlings not packed properly. Once the trees inside the plot are inspected and tallied, you will need to excavate seedlings outside of the plot to check for below-ground problems. Below-ground problems include improper planting angle of the root system (greater than 30° from vertical), "J" rooted seedlings, "L" rooted seedlings, twisted or balled roots, improper pruning, and cull seedlings (taproot less than 5 inches). For the first five plots two trees are sampled per plot. After these 10 trees are inspected, if there is over 10 percent below-ground problems, then begin to sample 4 trees per plot until you have 10 percent below-ground problems.

Once all of the plots are tallied, calculate the totals on the form.

$$\text{Total trees per acre} = \frac{\text{Total planted trees}}{\text{No. of plots}} \times 100$$

After taking out the unsatisfactory trees per acre, you have the total of satisfactory above-ground trees per acre. The excavation factor is derived by dividing the correct excavated seedlings by the total seedlings excavated. This factor is multiplied by the satisfactory above-ground trees per acre to determine the total planted trees per acre. This figure should be within 10 percent of the desired seedlings per acre for the planting job to be acceptable.

There is a large amount of time spent to inspect and evaluate the planting job; however, a much larger expense has been made to plant your seedlings. The job must be done correctly if you are to ensure a quality stand.

(Texas Forest Service)

FMD#61

PLANTING INSPECTION FORM

Field Tally

PLOT NO.	NATURAL TREES	TOTAL PLANTED TREES	UNSATISFACTORY TREES							SATIS-FACTORY TREES	EXCAVATED TREES				COMMENTS
			U	D	C	S	E	N							

Planting Problems

Above Ground

U - Unidentified cause of death
D - Debris, grass, leaves, or other material in the planting hole or furrow
C - Cull seedlings –
top less than 5 inches
root collar diameter less than 1/8th inch
lacking secondary needles
S - Shallow seedling (not planted deep enough) – root collar above ground roots showing above ground
E - Excessively deep seedling (planted too deep) – terminal bud less than 3 inches from the ground
N - Not packed properly –
too loose failed "four-needle test"
no second dibble hole
top of the planting hole not closed
bottom of the planting furrow not closed
seedling pushed over by packing wheels

Below Ground

X - Improper planting angle of the root system - greater than 30° from the vertical
J - J-rooted seedling
L - L-rooted seedling
T - Twisted or balled roots
P - Pruned improperly torn off lateral roots tap root pruned to less than 8 inches tap root pruned with a dull instrument
C - Cull seedlings – taproot less than 5 inches

Pest Problems

A - Town ant damage
W - Pales Weevil damage

M - Tip Moth damage

G - Pocket Gopher damage

B - Browsing damage (rabbit, deer, cattle)
F - Fusiform Rust

(Texas Forest Service)

Follow Pesticide Label Exactly

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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